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Evaluating a Dual-Process Model of Risk: Affect and Cognition as Determinants of Risky Choice

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ABSTRACT

In three studies we addressed the impact of perceived risk and negative affect on risky choice. In Study 1, we tested a model that included both perceived risk and negative affect as predictors of risky choice. Study 2 and Study 3 replicated these findings and examined the impact of affective versus cognitive processing modes. In all the three studies, both perceived risk and negative affect were shown to be significant predictors of risky choice. Furthermore, Study 2 and Study 3 showed that an affective processing mode strengthened the relation between negative affect and risky choice and that a cognitive processing mode strengthened the relation between perceived risk and risky choice. Together, these findings show support for the idea of a dual-process model of risky choice. Copyright © 2008 John Wiley & Sons, Ltd.

KEY WORDS risky choice; negative affect; perceived risk; decision making; dual-process

INTRODUCTION

When informing about a risk, how likely is the appeal to 'use one's head' to succeed when the evaluation of that risk appears to be more of a 'feeling thing'? Is information about the low probability of risks that trigger strong affective reactions (e.g. flying, terrorist attack) likely to have a comforting effect? Conversely, is it likely that probabilistic information is discomforting enough to persuade individuals not to engage in certain risky behaviour (e.g. drinking and driving, unprotected intercourse)? Or are appeals better directed at influencing feelings in these cases? In this paper we address the effects of both cognition and affect as determinants of risky choice and examine how and to what extent 'cool' cognitive considerations of and 'hot' feeling-based reactions to risky choice can influence the *way* we process risk.

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Standard decision theories have generally assumed people to decide on a certain course of action by making a mental calculation that incorporates the probability of the outcomes of a decision together with an evaluation of these outcomes. In the case of risky choice, people are supposed to combine the perceived severity of the outcomes of a choice with the perceived probability of their occurrence (e.g. Yates & Stone, 1992; Hendrickx, Vlek, & Oppewal, 1989; Vlek & Stallen, 1980). Deviations from these normative approaches have traditionally been accommodated in terms of cognitive biases, errors or the use of heuristics (Kahneman & Tversky, 1982; Simon, 1957; Tversky & Kahneman, 1974). More recent literature has also started addressing the possible role of affect as a determinant of risky choice.

An example is research that focused on the role of anticipated emotions such as disappointment and regret arising from counterfactual comparisons of potential decision outcomes (Bell, 1985; Loomes & Sugden, 1982, 1986; Mellers, Schwarz, Ho, & Ritov, 1999). However, the regret perspective focuses on anticipated emotions that come into play only after a choice has been made, rather than emotions present at the time of the decision and '(...) the decision-making process in these theories is still modeled as the implicitly cognitive task of predicting the nature and strength of future emotions in response to possible decision outcomes and weighing them according to their likelihood of occurring' (Loewenstein, Weber, Hsee, & Welch, 2001, p. 268).

Other research has addressed the direct influence of affect on how we evaluate risks. Johnson and Tversky (1983), for example, found that mood can influence individuals' risk judgments. People who were induced to feel positive affect made more optimistic risk estimates than people who were made to experience negative affect (Johnson & Tversky, 1983). Lerner and Keltner (2001) studied the influence of discrete emotions on risk perception and found fear and anger, both negatively valenced emotions, to have opposite effects. Angry people expressed more optimistic risk estimates and risk-seeking choices than did fearful individuals.

Finucane, Alhakami, Slovic, and Johnson (2000) provide evidence for an 'affect heuristic', which refers to the tendency to use an overall affective impression when making decisions. This, in their view, can be more efficient than weighing the different pros and cons of the situation because the reliance on affect helps to respond quickly and effectively in many decision situations, in particular when a judgment or decision is complex and mental resources are limited (Finucane et al., 2000; Slovic, Peters, Finucane, & MacGregor, 2005). The notion that individuals often rely on their feelings when faced with a decision and that affective reactions come prior to decisions and judgments was earlier proposed by Zajonc, who argued that 'feeling accompanies all cognitions' (1980, p. 154).

The possible interplay between cognition and affect has been prominent in dual-process theories of information processing (Chaiken & Trope, 1999; Epstein, 1994; Sloman, 1996), which revolve around the idea that when people make judgments and decisions or engage in problem solving, two qualitatively different modes of processing are operative. Some of these theories make the distinction between automatic versus more controlled modes of processing, whereas others argue for a more cognition-based versus a more affect-based processing mode (e.g. Chaiken & Trope, 1999; Epstein, 1994). Epstein (1994), for example, distinguishes an experiential system which is intimately associated with affect, 'but not to the exclusion of all non-affective cognitions' (p. 713), from a rational system which is 'relatively affect free' (p. 711).

Recent theorizing on risky decision-making draws from dual-process theories by arguing that there are two different modes in which risks are evaluated, one based more on deliberate and analytical considerations (as supposed by cognitive decision-making perspectives), the other based on intuitive, relatively fast and affect-based reasoning (e.g. Kahneman, 2003; Kahneman & Frederick, 2002; Slovic et al., 2005). Slovic and collaborators termed these two ways in which risks are perceived and acted on as 'risk-as-analysis' and 'risk-as-feelings', respectively (Slovic et al., 2005). The dual-process approaches to risky choice thus share the idea of two modes of processing that interact and that are continually active, but respond to different characteristics of a situation. The cognitive mode is supposed to be sensitive to risk considerations such as outcomes and probabilities, whereas the feeling-based mode responds to affective considerations, and is not responsive to probabilities (Slovic et al., 2005). The fact that the different processing modes respond to

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different characteristics of a situation also illuminates why affective reactions to risky situations and decisions can diverge from cognitive considerations: 'People can experience powerful fears about things that they recognize as highly unlikely (such as airplane crashes) or not objectively terrible (such as public speaking); in contrast, many experience little fear about hazards that are both more likely and probably more severe (such as car accidents)' (Loewenstein et al., 2001, p. 269).

The dual-process notion of risky choice is compatible with the 'risk-as-feelings' hypothesis by Loewenstein and collaborators, which also acknowledges the role of affect besides probability and outcome valences in the decision-making process, and argues that affect influences decision-making amongst others through the interaction with cognition where the former influences the latter and vice versa (Loewenstein et al., 2001). One of the principal assumptions of the risk-as-feelings hypothesis is that '[t]he impact of cognitive evaluations on behaviour is mediated, at least in part, by affective responses (cognitive evaluation gives rise to feelings that in turn affect behaviour)' (p. 271).

In sum, studies have shown that both cognitive considerations and affective reactions can influence risk perception and risky choice. Furthermore, there is empirical support for the idea of two parallel modes of information processing in a variety of domains, including judgment and decision-making. However, (1) the case for the dual-process approach with respect to risky choice has been made, but not tested. Additionally, (2) little is known as to what extent people can be induced to rely more on either their feelings or their thoughts when faced with a risky choice. Both issues form the objectives of the present paper. We present a model that includes and simultaneously tests perceived risk and negative affect as predictors of risky choice and examine how the two are related by manipulating them separately.

In Study 1, we investigated the role of perceived risk and negative affect as predictors of risky choice using vignettes containing descriptions of risky situations. We expected both perceived risk and negative affect to be significant predictors of risky choice.

STUDY 1

Method

Participants and procedure

Participants were 231 undergraduate students (68 males, 163 females) with a mean age of 22.5 years (SD = 6.1 years) from the University of Amsterdam who participated for course credit. Participants were randomly presented one of two booklet versions, each containing two vignettes and two questionnaires. Within each booklet the order in which the vignettes were presented was counterbalanced. The booklets started with a short introduction in which the participants were told that they would read about two risky choice situations, and asked to answer the questions pertaining to the descriptions.

Materials

The vignettes contained a description of a personally relevant risky situation of about 8–10 lines (see Appendix). The topics of the vignettes ranged from riding in a car with a driver who has been drinking (Drink 'n Drive), flying with an airline that has been warned for the bad maintenance of its aircraft (Airplane), biking on slippery streets (Exams) and running the risk of being fined for not carrying an ID (Going Out). An attempt was made to design vignettes that were personally relevant for the participants and that varied both in terms of the nature of the risk and the severity of its consequences (e.g. getting a fine, suffering severe injuries). The 'Drink 'n Drive' scenario, for example, read as follows:

> '*Imagine the following:* You are at a birthday party an hour's drive from your home. You agreed with a friend, with whom you are at the party, that he/she would drive you back home since you don't have a

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drivers licence. When the party is over, you notice that your friend is quite drunk. There is nobody at the party from your hometown who can give you a ride, and there is no public transport. You deliberately stayed sober because you have an important job interview in the morning'.

Each vignette was followed by eight items measuring perceived risk, negative affect and the dependent variable, risky choice. In all cases bipolar 9-point scales were used. Two items measured perceived risk. One item pertained to risk probability: 'How big are the chances of X happening (e.g. having an accident)?' *(very small–very big*). The other item concerned risk magnitude: 'How serious are the possible consequences of X (e.g. getting into the car with your friend driving)?' (*not serious at all–very serious)*. The perceived risk score was obtained by multiplying these two items in correspondence with the formal definition of risk (Loewenstein et al., 2001; Yates & Stone, 1992).

Four items measured negative affect:'Would you be worried in this situation?', 'Does the situation make you feel uncertain?', 'Does the situation evoke feelings of fear?' and 'Does the situation evoke negative feelings in general?' *(not at all–very much)*. Cronbach's alpha of the negative affect scale in the four vignettes ranged from 0.83 to 0.92. The outcome variable, risky choice, was measured with two items. The first item inquired about the likelihood that the participant would engage in the risky behaviour: 'How likely is it that you would go for option/do X (e.g. get into the car with your friend driving)?' (*very unlikely–very likely*). The second item measured certainty: 'How certain are you about this?' (*not at all–completely*). The likelihood item was recoded to a scale that ranged from -4 to $+4$ and the risky choice score was computed by multiplying the recoded likelihood item with the certainty item, so that the scores could range from -36 to $+36$.

Results

In Table 1, the means and standard deviations of perceived risk, negative affect and the outcome variable risky choice for each of the four vignettes are displayed. In Table 2, the correlations between the predictor variables and the risky choice are shown. All of the correlations in each of the four vignettes are significant at $p < 0.01$.

To test for the relations between perceived risk and negative affect on the one hand and risky choice on the other, in all four vignettes at once we conducted multigroup structural equation modeling (SEM) using AMOS 7.0 (Arbuckle, 2006). We constructed three latent variables, of which negative affect was measured using four indicators, perceived risk was measured using one indicator based on the probability $\times$ magnitude multiplication, and risky choice likewise was measured using one indicator based on the likelihood $\times$ certainty multiplication (see 'method' section). Because no reliability information was available for the two multiplicative indicators, we fixed the measurement weights linking perceived risk and risky choice to their respective indicators to be equal to one.

We compared eight different SEM models (see Table 3): (1) a model in which none of the variables were related to each other (the independent model), (2) a model in which the hypothesized relations between the

Table 1. Descriptives of perceived risk, negative affect and risky choice (Study 1)

	Airplane	Exams	Drink 'n Drive	Going Out
Variables	*M* (SD)	*M* (SD)	*M* (SD)	*M* (SD)
1. Perceived risk	32.05 (19.13)	31.46 (17.36)	42.78 (19.15)	39.28 (19.28)
2. Negative affect	6.26 (1.98)	4.80 (1.74)	6.81 (1.51)	5.37 (1.56)
3. Risky choice	5.19 (17.06)	19.41 (14.14)	−9.39 (18.29)	7.29 (17.52)

Note: The labels 'Airplane', 'Exams', 'Drink 'n Drive', and 'Going Out' refer to the names of the vignettes. The possible range of the different scales is explained in the text.

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Table 2. Correlations of perceived risk, negative affect and risky choice (Study 1)

Variables	Airplane 1	Airplane 2	Airplane 3	Drink 'n Drive 1	Drink 'n Drive 2	Drink 'n Drive 3
1. Perceived risk	—			—		
2. Negative affect	0.66**	—		0.66**	—	
3. Risky choice	−0.50**	−0.53**	—	−0.51**	−0.50**	—
	Exams			Going Out		
1. Perceived risk	—			—		
2. Negative affect	0.59**	—		0.56**	—	
3. Risky choice	−0.51**	−0.49**	—	−0.45**	−0.51**	—

*$p < 0.05$; **$p < 0.01$.

variables (see Figure 1) were allowed to vary between the four vignettes (the unconstrained model), (3) a model in which the measurement weights were fixed to be equal across the four vignettes, but the rest of the parameters were free across the four vignettes (the measurement weights model (3a)), (4) a model in which both the measurement weights and the structural paths connecting the latent exogenous variables to the latent endogenous variable were fixed to be equal across the four vignettes (the structural weights model (3b)), (5) a model in which all previous weights and all structural variances and covariance were fixed to be equal across the four vignettes (the structural (co)variances model (3c)), (6) a model in which all previous weights and (co)variances and the structural residual ($\zeta 1$) were fixed to be equal across the four vignettes (the structural residuals model (3d)) and (7) a model in which all parameters (i.e. including the measurement residuals (δ and ε)) were fixed to be equal across the four vignettes (the measurement residuals model (3e)).

In Table 3, the results of the analyses on the seven models are described. Based on the fit indices, we selected a model with a Tucker-Lewis Index (TLI) of 0.90 or above, a root mean square error of approximation (RMSEA) of 0.05 or below, or if not possible, a *p*-close value of 0.01 or higher, and preferably a Parsimony Comparative Fit Index (PCFI) of 0.90 or above. Furthermore, we compared the different models described above using a significance test of the increase in χ^2 when additional parameters were fixed. A significant increase in χ^2 signifies that constrained (nested) models are significantly worse. Considering the parsimony of nested models, we used a somewhat conservative value of $p < 0.01$ for the significance test. Applied to the nested models in Table 3, we found that model 3a was not significantly worse than model 2 ($\Delta\chi^2_{(df=9)} = 10.91$, $p = 0.28$), model 3b was not significantly worse than model 3a ($\Delta\chi^2_{(df=6)} = 8.28$, $p = 0.22$), model 3c was not significantly worse than model 3b ($\Delta\chi^2_{(df=9)} = 16.10$, $p = 0.07$), model 3d was

Table 3. Comparison of fit indices of different models (Study 1)

	χ^2	df	*p*	TLI	RMSEA	90% CI	*p*-close	PCFI
1. Independent	1538.79	60	0.00	0.00	0.232	0.222–0.242	0.00	0.00
2. Unconstrained	73.55	32	0.00	0.95	0.053	0.037–0.069	0.35	0.52
3. Constrained								
(a) Measurement weights (λ's)	84.45	41	0.00	0.96	0.048	0.033–0.063	0.57	0.66
(b) 3a + Structural weights (γ's)	92.73	47	0.00	0.96	0.046	0.032–0.060	0.66	0.76
(c) 3b + Structural (co)variances (Φ)	108.83	56	0.00	0.96	0.045	0.032–0.058	0.71	0.90
(d) 3c + Structural residuals (Ψ)	**117.67**	**59**	**0.00**	**0.96**	**0.047**	**0.034–0.059**	**0.66**	**0.94**
(e) 3d + measurement residuals (Θ_δ)	209.14	71	0.00	0.92	0.065	0.055–0.075	0.01	10.07

Note: The structural residuals model (3d) in boldface is selected as the 'best' model and is represented in Figure 1.

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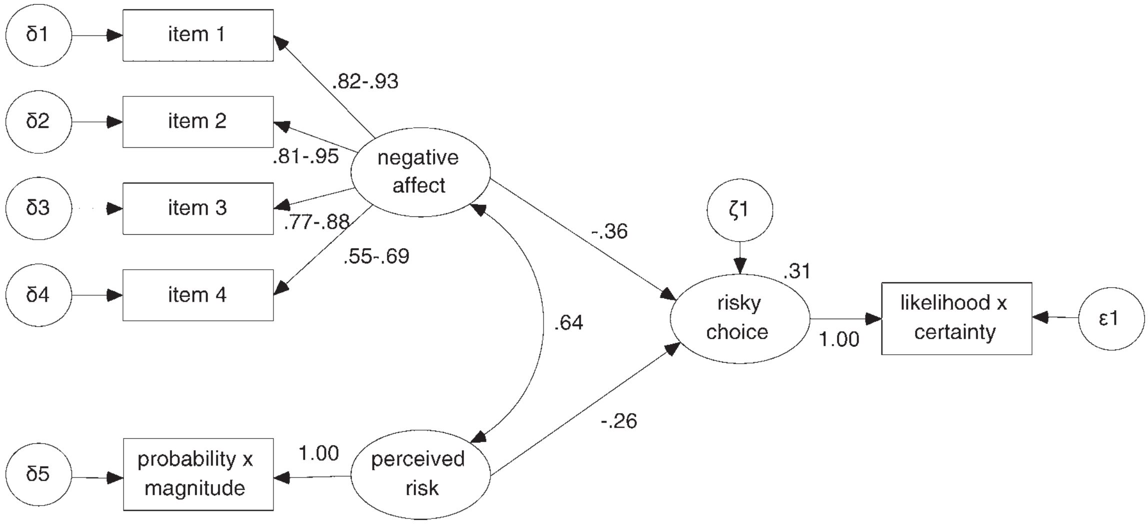

Figure 1. Standardized estimates in the structural residuals model (model 3d in Table 3) of relations between perceived risk, negative affect, and risky choice (Study 1, see text for explanation)

not significantly worse at the $p < 0.01$ level than model 3c ($\Delta\chi^2_{(df=3)} = 8.84$, $p = 0.03$), but model 3e was significantly worse than model 3d ($\Delta\chi^2_{(df=12)} = 91.47$, $p < 0.01$).

On grounds of parsimony combined with the other fit indices, the structural residuals model (model 3d, see Table 3) appears to be the 'best' model. This model is shown in Figure 1. Because the measurement residuals were not equal across vignettes, the range (instead of the exact values) of the measurement weights (λ's) linking negative affect with its indicators are shown. However, differences in measurement residuals across groups do not affect the structural paths from the latent exogenous variables to the latent endogenous variable. The standardized structural coefficient linking negative affect and risky choice ($\gamma = -0.36$) and the standardized structural coefficient linking perceived risk and risky choice ($\gamma = -0.26$) were found to be significant at $p < 0.01$. Additionally, there was a significant relation between negative affect and perceived risk ($\varphi = 0.64$, $p < 0.01$).

Conclusion

Study 1 examined the influence of negative affect and perceived risk on risky choice in a straightforward manner. In all four vignettes, perceived risk and negative affect were found to be significantly negatively related to risky choice. However, Study 1 did not include any manipulations of cognitions or affect, and consequently, it is therefore yet unclear under what circumstances the effects of cognitions and affect can be strengthened or reduced. In Study 2, we aimed to replicate these findings and to provide further support for a distinction between affect and cognition by experimentally manipulating the salience of affective versus more cognitive information.

STUDY 2

According to Higgins (1996), activated knowledge affects our judgments when that knowledge is related to the stimulus information because it has become more accessible. When knowledge is activated, it increases

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the likelihood that this knowledge will be used in some way and therefore influences subsequent responses to stimuli (Higgins, 1996; Higgins, Rholes & Jones, 1977). An interesting question in this respect regards the extent to which it is possible to render cognition or affect more salient through the description of a risky situation and whether this could influence the evaluation of the situation reflecting the salience of either the affective or the cognitive component. Sunstein (2003), for instance, found that people were willing to pay more for the elimination of a certain risk (i.e. risk of cancer due to arsenic in drinking water) when having read a description of the risk that contained an added sentence containing vivid terms, than people who just read the 'plain' description. This implies that the way in which risks are described can influence the judgment of risks. Furthermore, Hendrickx et al. (1989) found that people judged risks as more probable and were also less inclined to make risky choices when presented with information about *how* a future loss or accident might occur than when presented with information about the relative frequency of similar accidents in the past. The explanation for this effect according to Loewenstein et al. (2001) is that the vividness of the imagery evoked by the description of potential future losses, as opposed to 'cold' frequency estimates, is an important determinant of emotional reactions and is therefore likely to also trigger changes in risk perception and decisions.

In another study, Berndsen and Van der Pligt (2005) examined the impact of an affective focus versus a cognitive focus on risk perception and acceptance of meat consumption by presenting participants with risk descriptions in bogus newspaper articles phrased in either more affective or more cognitive terms. Based on the ideas put forward by Higgins et al. (1977), they expected that exposure to cognitive or affective stimulus information would affect perceptions of health risks and found that an affective focus had a stronger impact than a more cognitive focus.

In Study 2, we investigated whether adding cognitive versus affective information to a description of a risk can make this information more predictive of risky choice. We expected a stronger relation between negative affect and risky choice in the affect condition, and a stronger relation between perceived risk and risky choice in the cognition condition.

Method

Participants and procedure

A total of 193 undergraduate students, 56 men and 137 women, from the University of Amsterdam with a mean age of 20.6 years ($SD = 2.9$ years) participated for course credit. Participants were randomly assigned to either the cognition or the affect condition and received a booklet with two vignettes, the order of which was again counterbalanced. Participants were randomly assigned to an individual cubicle where the booklets were included in a set of unrelated questionnaires.

Materials

We used two of the vignettes (Drink 'n Drive and Going Out) from Study 1. The two vignettes were supplemented with two sentences of extra information that were intended to render either cognition or affect salient. The sentences were identical except for two references to either cognition-related words (e.g. references to frequencies or probabilities) or affect-laden words (e.g. references to feelings and emotions). This information contained no references to either the likelihood or the severity of the risk itself and the added text was related to the risk description, but purposefully ambiguous. For the 'Drink 'n Drive' vignette presented earlier the added information in the cognition condition read:

> The *number of people* that drive with a too high blood alcohol concentration has decreased in recent years. The reason for this is not so much the possibility of getting a fine, but rather the *chance* of having an accident.

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In the affect condition it read as follows:

> The *anxiety of people* for driving with a too high blood alcohol concentration has increased in recent years. The reason for this is not so much the possibility of getting a fine, but rather people's *worries* about having an accident.

The items and scales for the predictor and outcome variables were identical to the ones used in Study 1. Cronbach's alpha for the negative affect scales was 0.87 for Drink 'n Drive and 0.96 for Going Out. Finally, in order to assess the perceived strength of the cognitive and affective manipulations, participants were asked how convincing they found the vignettes and to what extent they could imagine themselves being in the described situation.

Results

One participant indicated not to have participated seriously and was excluded from further analyses. The strength of the manipulations was measured with *t*-tests. No differences were found between the conditions for either the item measuring the extent to which the vignette was convincing or the item pertaining to the extent to which the risky situation was imaginable. From this we conclude that the intensity of the manipulations was equal for both the affect and cognition conditions and the results therefore cannot be attributed to differences in intensity of the cognition or affect manipulation. Furthermore, as can be seen in Table 4, there were no significant differences in means between conditions for the predictor variables and the outcome variable for either vignette. In Table 4, moderate to strong correlations are shown between the predictor variables, negative affect and perceived risk and the outcome variable risky choice for both vignettes.

We predicted that in the cognition condition, perceived risk would be more strongly related to risky choice relative to the affect condition, whereas negative affect would be more strongly related to risky choice in the affect condition, relative to the cognition condition. As in Study 1, to test this prediction we used multigroup structural equation modelling (SEM) using AMOS 7.0 (Arbuckle, 2006). Again we considered eight different models. In some of these models we freed up the structural paths linking the exogenous latent variables negative affect and perceived risk with the endogenous latent variable risky choice across the two

Table 4. Descriptives and correlations of perceived risk, negative affect and risky choice for Drink 'n Drive and Going Out (Study 2)

	Drink 'n Drive		Going Out				
	M (SD)		*M* (SD)				
Variables[a]	Cognition[b]	Affect[c]	Cognition[b]	Affect[c]	1	2	3
1. PR	41.95 (18.83)	44.88 (18.24)	40.69 (18.66)	42.21 (20.31)	—	0.59**	−0.60**
2. NA	6.89 (1.60)	7.19 (1.55)	5.56 (1.73)	5.83 (1.77)	0.42**	—	−0.61**
4. RC	−8.7 (17.79)	−12.73 (18.00)	5.20 (15.59)	2.28 (19.49)	−0.51**	−0.49**	—

[a]PR = perceived risk, NA = negative affect, RC = risky choice.
[b]Cognition condition.
[c]Affect condition.
Correlations of both conditions in the Drink 'n Drive sample are shown above the diagonal; those of both conditions in the Going Out sample are shown below the diagonal. The possible range of the different scales is explained in the text.
$^{*}p < 0.05$; $^{**}p < 0.01$.

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Table 5. Comparison of fit indices of different models (Study 2)

	χ^2	df	p	TLI	RMSEA	90% CI	p-close	PCFI
1. Independent	1420.15	60	0.00	0.00	0.244	0.233–0.255	0.00	0.00
2. Unconstrained	49.39	32	0.03	0.98	0.038	0.014–0.058	0.83	0.53
3. Constrained								
(a) Measurement weights (λ's)	65.17	41	0.01	0.97	0.039	0.020–0.057	0.83	0.67
(b) 3a + Structural weights (2 γ's free: see text)	67.60	45	0.02	0.98	0.036	0.016–0.053	0.90	0.74
(c) 3b + Structural (co)variances (Φ)	78.15	54	0.02	0.98	0.034	0.015–0.050	0.95	0.88
(d) 3c + Structural residuals (Ψ)	**81.70**	**57**	**0.02**	**0.98**	**0.034**	**0.015–0.049**	**0.96**	**0.93**
(e) 3d + 2 γ's constrained	93.93	59	0.00	0.97	0.039	0.024–0.054	0.88	0.96
(f) 3e + Measurement residuals (Θ_δ)	240.21	71	0.00	0.89	0.079	0.068–0.090	0.00	10.04

Note: The structural residuals model (3d) in boldface is selected as the 'best' model and is represented in Figure 2.

experimental conditions to check whether these models fared better than models in which these paths were constrained to be equal across the two experimental conditions. The first three SEM models we considered (models 1, 2 and 3a, see Table 5) are the same as the SEM models considered in Table 3 of Study 1. However, in the fourth model (model 3b) we allowed the structural paths in the affect condition to be different from the structural paths in the cognition condition. Note that the structural paths between the vignettes in the same condition were fixed to be equal. The fifth (3c) and sixth (3d) models were similar to model 3b but now with additional structural (co)variances (3c) or structural (co)variances plus structural residuals (3d) fixed to be equal across the vignettes. The seventh (3e) model was equal to model 3d, but now the two parameters which were freed up across the two conditions in model 3b, 3c and 3d were fixed to be equal. In model eight (3f), all parameters were constrained to be equal across vignettes similar to model 3e in study 1 (Table 3).

The results are reported in Table 5. Similar fit indices and cut-off points were used as in Study 1, that is, TLI > 0.90, RMSEA < 0.05 or p-close > 0.01 and a PCFI > 0.90. Additionally, we checked whether consecutive models in Table 5 were not less worse (i.e. 'better' because more parsimonious) than previous

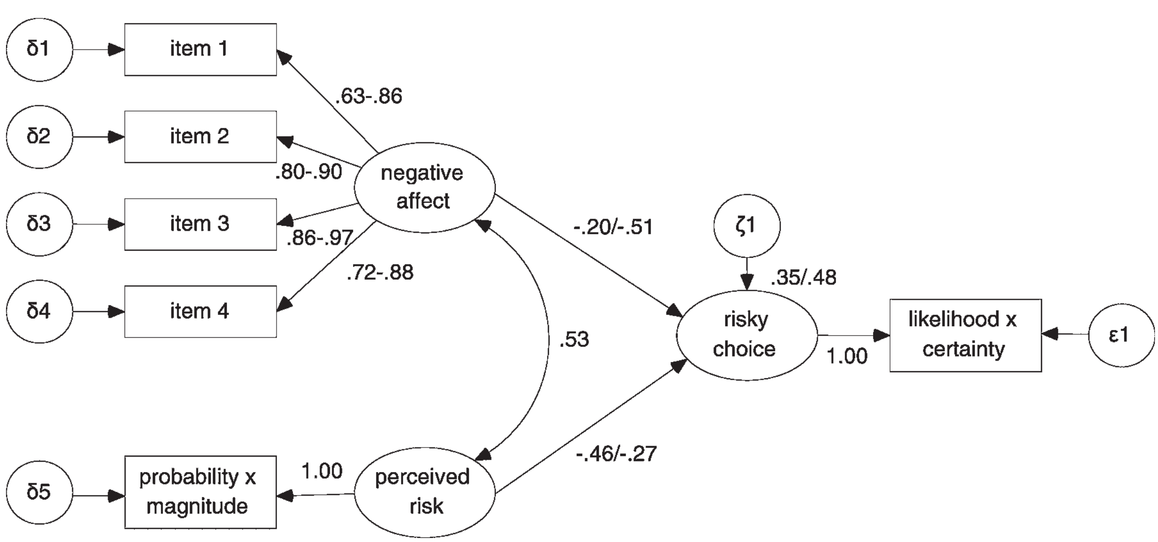

Figure 2. Standardized estimates in the structural residuals model (model 3d in Table 5). The γ's linking negative affect and perceived risk with risky choice are for the cognitive (left γ)/affect (right γ) conditions respectively (Study 2, see text for additional explanation)

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models. This resulted in the following model improvements/deteriorations. Model 3a was not significantly worse than model 2 ($\Delta\chi^2_{(df=9)} = 15.77$, $p = 0.07$), model 3b was not significantly worse than model 3a ($\Delta\chi^2_{(df=4)} = 2.44$, $p = 0.66$), model 3c was not significantly worse than model 3b ($\Delta\chi^2_{(df=9)} = 10.55$, $p = 0.31$), model 3d was not significantly worse than model 3c ($\Delta\chi^2_{(df=3)} = 3.56$, $p = 0.31$), but model 3e was significantly worse than model 3d ($\Delta\chi^2_{(df=2)} = 12.23$, $p < 0.01$) and model 3f was significantly worse than model 3e ($\Delta\chi^2_{(df=12)} = 146.28$, $p < 0.01$).

Based on these model comparisons, the fit indices and parsimony, the structural residuals model with the structural paths freed across the two (cognition and affect) conditions (model 3d, see Table 5) appears to be the 'best' model. This model is represented in Figure 2. Again, as in Study 1, because the measurement residuals were not found to be equal across vignettes, we report the range of values of the measurement weights (λ's) linking negative affect with its indicators. In Figure 2, the values of the standardized structural paths in the two conditions are also shown. The leftmost value of the standardized structural paths is associated with the cognitive condition, the rightmost value with the affect condition. All of the values reported are significant at $p < 0.01$. As can be seen, in the cognitive condition the standardized path coefficient linking perceived risk and risky choice ($\gamma = -0.46$) was stronger than in the affect condition ($\gamma = -0.27$). Additionally, in the cognitive condition the standardized path coefficient linking negative affect and risky choice ($\gamma = -0.20$) was weaker than in the affect condition ($\gamma = -0.51$). Because this model (3d, see Table 5) was significantly better than a model in which these parameters were constrained to be equal (model 3e), we conclude that our expectations were confirmed.

Conclusion

The results again showed both negative affect and perceived risk to be significantly related to risky choice. Furthermore, in line with our expectations, it was shown that in the cognition condition, perceived risk was more strongly related to risky choice relative to the affect condition, whereas negative affect was more strongly related to risky choice in the affect condition, relative to the cognition condition, thereby providing further support for a dual-process model of risky choice. Study 2 contained an obtrusive manipulation of cognitive and affective modes. In Study 3, we investigated whether it is possible to get similar results using an unobtrusive manipulation.

STUDY 3

In this Study 3, we examined whether activating a cognitive or affective processing mode by means of a priming task also leads to risk evaluation primarily based on cognition or affect. Hsee and Rottenstreich (2004) primed a cognitive processing mode ('valuation by calculation') by asking participants to answer questions that required conscious and deliberate calculation and an affective processing mode ('valuation by feeling') by presenting participants questions that required them to examine and report their feelings. They found that valuation by calculation made people sensitive to variations in scope, whereas valuation by feeling made people insensitive to scope, but sensitive to the presence or absence of a stimulus instead.

In another recent study, the impact of affect and cognition was investigated in the context of attitudes (Van de Berg, Manstead, Van der Pligt, & Wigboldus, 2006). They attempted to activate either a cognitive or affective processing mode in an unobtrusive manner by priming words related to affect (e.g. the word 'feeling') or cognition (e.g. the word 'thinking'). In Study 3, we adopted this approach and investigated whether this less obtrusive manipulation of processing mode results in risk evaluations on either a more cognitive or more affective basis. Finding evidence for this assumption would lend further support to the risk-as-feelings versus risk-as-analysis distinction and would also be in line with other dual-process approaches, providing additional evidence for the two suggested ways in which risks can be evaluated.

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To prime processing mode, participants were asked to solve a word-search puzzle that contained words that were related to either affect or to cognition. Subsequently, in a supposedly unrelated experiment, participants were presented two of the vignettes used in Study 1 (Airplane and Exams). The expectations were similar to those of Study 2. Negative affect was expected to be a better predictor of risky choice when participants are induced to use a more affective processing mode. Similar expectations applied to the cognitive processing mode; in this mode we expected cognitive appraisal of risk to more strongly predict risky choice relative to affective appraisal of risk. In sum, primed processing mode should enhance the relations between the appraisal of risk in that mode and risky choice.

Method

Participants and procedure

A total of 201 undergraduate students, 58 male and 143 female, with an average age of 20.2 years (SD = 2.1 years) from the University of Amsterdam participated for course credit. Participants were randomly assigned to either the cognition or affect condition. Within these conditions, participants were again randomly presented one of two booklet versions containing two vignettes in counterbalanced order. The puzzle and the risk vignettes were included in a set of questionnaires that, aside from the materials used in the present study, were unrelated.

Materials

To prime processing mode and make either affect or cognition salient, participants worked for 5 minutes on a word-search puzzle developed by Van de Berg et al. (2006). The puzzle consisted of a 15 by 15 letter matrix in which participants searched for hidden words. Words could be hidden from top to bottom, from bottom to top, from left to right, from right to left or diagonally. Participants were asked to mark the words they found. In order to make the puzzle and vignettes seem unrelated, the instructions read that the goal of the puzzle task was to see which words were found first by the participants and that they therefore had to also indicate the order in which they found the different words. The seven words that had to be found were listed next to the puzzle. In the affect condition, participants searched for the (Dutch translations of the) following words: ‘feeling’, ‘emotion’, ‘sensation’, ‘state of mind’, ‘intuition’, ‘impression’ and ‘experiencing’. In the cognition condition, participants searched for ‘thinking’, ‘logic’, ‘analyzing’, ‘rational’, ‘knowing’, ‘mind’ and ‘reasoning’.

The items and scales of the predictors and the dependent variable were identical to those used in the previous studies. Cronbach’s alpha for the negative affect scales was 0.92 for the Airplane vignette and 0.86 for the Exams vignette.

Results

Two participants indicated not to have participated seriously and were excluded from further analyses. Three other participants only found five or less of the seven words that were hidden in the puzzle. Because it was unclear whether they had skipped the remainder of the puzzle or were indeed unable to find the words, it was decided to exclude them from the analyses as well. In Table 6, the means, standard deviations and correlations for the predictors and the outcome variable for both conditions are displayed. For the Exams vignette, there was a significant difference for perceived risk as participants scored higher on this variable in the affect condition. There were no other significant differences in the means between conditions. In correspondence with Studies 1 and 2, the results showed moderate to strong correlations between the predictor variables, negative affect and perceived risk and the outcome variable risky choice for both vignettes.

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Table 6. Descriptives and correlations of perceived risk, negative affect and risky choice (Study 3)

	Airplane		Exams				
	M (SD)		*M* (SD)				
Variables[a]	Cognition[1]	Affect[2]	Cognition	Affect	1	2	3
1. PR	32.03 (17.78)	32.18 (16.83)	28.51 (13.27)	33.76 (17.72)[†]	—	0.59**	−0.64**
2. NA	6.25 (1.75)	6.62 (1.73)	4.75 (1.50)	5.18 (1.77)	0.54**	—	−0.65**
3. RC	4.04 (16.57)	3.52 (13.88)	21.25 (10.37)	17.82 (14.54)	−0.39**	−0.43**	—

[a]PR = perceived risk, NA = negative affect, RC = risky choice.
[1]Cognitive condition.
[2]Affect condition.
[†]Mean (between conditions within a vignette) is significantly higher at $p < 0.05$.
Correlations of both conditions in the Airplane sample are shown above the diagonal; those of both conditions in the Exams sample are shown below the diagonal. The possible range of the different scales is explained in the text.
*$p < 0.05$; **$p < 0.01$.

As in Study 2, we tested the prediction that in the affect condition risky choice is more strongly related to negative affect relative to the cognition condition, whereas in the latter condition, risky choice is better predicted by perceived risk compared to the affect condition. Similar to Study 2, we formulated a number of structural equation models (SEM's), in which parameters were either freed up or constrained across the different vignettes and conditions. The models, which are the same as the ones explained in Study 2, are presented in Table 7. Again, we used the following cut-off values and model comparison statistics to select our final model. The cut-off values for the fit indices were: TLI > 0.90, RMSEA < 0.05 or *p*-close > 0.01 and PCFI > 0.90. When comparing the models represented in Table 7, we found model 3a not to be significantly worse (at $p < 0.01$) than the unconstrained model 2 ($\Delta\chi^2_{(df=9)} = 22.08$, $p = 0.01$). However, model 3b was significantly worse than model 3a ($\Delta\chi^2_{(df=4)} = 23.28$, $p < 0.01$). Model 3c fared better, it was not significantly worse (at $p < 0.01$) than model 3b ($\Delta\chi^2_{(df=9)} = 18.48$, $p = 0.03$). Model 3d was not significantly worse than model 3c ($\Delta\chi^2_{(df=3)} = 3.93$, $p = 0.12$), but model 3e was significantly worse than model 3d ($\Delta\chi^2_{(df=2)} = 14.54$, $p < 0.01$), and model 3f was significantly worse than model 3e ($\Delta\chi^2_{(df=12)} = 58.04$, $p < 0.01$).

In contrast to Study 1 and Study 2, in this study we were unable to unambiguously asign a 'best' model based on the fit criteria and model comparison statistics. Based on model comparison, we should have selected the measurement weights model. This model also performed slightly better in terms of the TLI and RMSEA criteria. However, it performed much worse on the parsimony fit index PCFI. When we compared

Table 7. Comparison of fit indices of different models in Study 3

	χ^2	df	*p*	TLI	RMSEA	90% CI	*p*-close	PCFI
1. Independent	1506.49	60	0.00	0.00	0.246	0.235–0.257	0.00	0.00
2. Unconstrained	90.70	32	0.00	0.92	0.068	0.052–0.085	0.04	0.51
3. Constrained								
(a) Measurement weights (λ's)	112.78	41	0.00	0.93	0.066	0.052–0.081	0.03	0.65
(b) 3a + Structural weights (2 γ's free: see text)	136.06	45	0.00	0.92	0.071	0.058–0.085	0.01	0.70
(c) 3b + Structural (co)variances (Φ)	154.55	54	0.00	0.92	0.068	0.056–0.081	0.01	0.84
(d) 3c + Structural residuals (Ψ)	**160.47**	**57**	**0.00**	**0.92**	**0.068**	**0.055–0.080**	**0.01**	**0.88**
(e) 3d + 2 γ's constrained	175.01	59	0.00	0.92	0.070	0.058–0.082	0.00	0.90
(f) 3e + Measurement residuals (Θ_δ)	233.05	71	0.00	0.91	0.076	0.065–0.087	0.00	10.05

Note: The structural residuals model (3d) in boldface is selected as the 'best' model and is represented in Figure 3.

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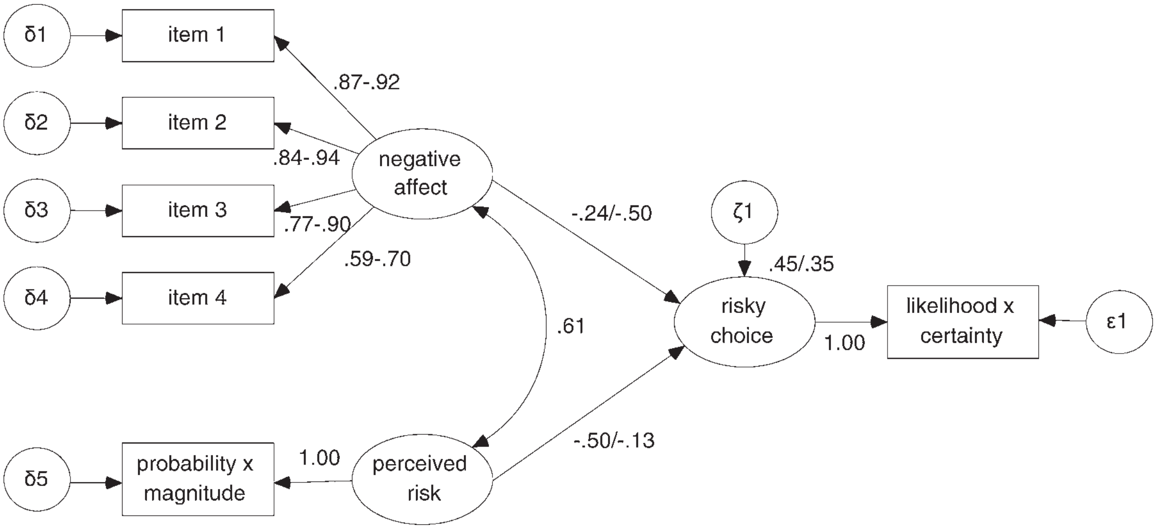

Figure 3. Standardized estimates in the structural residuals model (model 3d in Table 7). The γ's linking negative affect and perceived risk with risky choice are for the cognitive (left γ)/affect (right γ) conditions respectively (Study 3, see text for additional explanation)

models that were more parsimonious, the structural residuals model with two free structural paths (model 3d) performed best. The consecutive models 3e and 3f, in which the two parameters were constrained to be equal across the two experimental conditions fared significantly worse than model 3d in which these two parameters were allowed to be free. Because the TLI and RMSEA/*p*-close values were not much worse, and because the PCFI approached the value of 0.90, we opted for this model, which is displayed in Figure 3.

In Figure 3, again the leftmost value of the standardized structural paths is associated with the cognitive condition, the rightmost value with the affect condition. Except for the structural path in the affect condition from perceived risk to risky choice ($\gamma = -0.13, p = 0.09$), all of the values reported are significant at $p < 0.01$. In the cognitive condition, the standardized path coefficient linking perceived risk and risky choice ($\gamma = -0.50$) was stronger than in the affect condition ($\gamma = -0.13$). Additionally, in the cognitive condition the standardized path coefficient linking negative affect and risky choice ($\gamma = -0.24$) was weaker than in the affect condition ($\gamma = -0.50$). Because the model in which the parameters were freed up across experimental conditions (model 3d, see Table 7) performed significantly better than the model in which these parameters were constrained to be equal (model 3e), we can conclude that our expectations were confirmed.

Conclusion

Analogous to the results of Study 1 and Study 2, the results of Study 3 showed both negative affect and perceived risk to be related to risky choice. Furthermore, in line with the results of Study 2, in the affect condition, negative affect was more strongly related to risky choice than perceived risk, whereas in the cognitive condition, perceived risk was more strongly related to risky choice than negative affect.

GENERAL DISCUSSION

In this paper, we examined the influence of perceived risk and negative affect on risky choice in different ways and found support for a dual-process model of risky choice based on affective and cognitive

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considerations. In Study 1, we found negative affect and perceived risk to simultaneously influence risky choice. These findings were replicated in Study 2 and Study 3. Although the findings are important in their own right, from Study 1 alone it can not be ascertained under what specific circumstances cognitions and affect are related—or not—to risky choice. For that purpose we designed two additional studies. Study 2, in which cognitions and affect were manipulated, showed that making affect salient by adding affective information to the description of a risk leads to increases in negative affect as a predictor of risky choice, whereas adding cognitive information to the description makes perceived risk more predictive of risky choice. Study 3 showed that the way a risk is processed can also be influenced by unobtrusively activating a cognitive or affective processing mode, which, in correspondence with the processing mode activated, increases the relative weight of either perceived risk or negative affect as predictors of risky choice. In other words, Studies 2 and 3 show that it is possible to influence the strengths of cognition and affect as predictors of risky choice, and in different—obtrusive and unobtrusive—ways.

These findings extend previous research in various ways. As was mentioned in the introduction, both cognitive considerations and affective reactions already had been demonstrated to influence risk perception and risky choice. Furthermore, the theoretical underpinnings of dual-processing models have also acquired empirical basis. Yet, evidence for separate modes of information processing with respect to risk evaluation and risky choice has neither been reported in the literature nor has been examined to what extent people can be made to rely on a 'risk-as-feelings' or 'risk-as-analysis' strategy. Even though studies have shown the nature of presented information (e.g. statistical versus anecdotal or abstract versus specific) can influence risk perception and/or risky choice, the affect versus cognition distinction used in our study has not been examined before. Finally, the unobtrusive priming of cognitive and affective processing strategies has been done in the context of attitudes and the valuation of stimuli, but is new with respect to risk processing.

Considered in conjunction the results of the three studies make a strong case not only for taking up affect in models of risky choice but also for considering risky decision-making as subject to dual modes of information processing. The findings show that people can be made to rely more on either their feelings or their thoughts through the addition of cognitive or more affective information to a description of a risk. Furthermore, the results of Study 3 demonstrate that it is possible to influence the way risk information is processed unobtrusively by means of a priming task unrelated to the risk. In other words, the mode in which risk information is processed can be influenced both in subtle and also relatively straightforward ways. The findings from Study 2 and Study 3 also demonstrate that affect-based and cognition-based modes can be manipulated independently from each other. This, additionally, extends previous research on attitudes (Van de Berg et al., 2006) and the valuation of stimuli (Hsee & Rottenstreich, 2004), and shows that processing mode can also be related to risk. Finally, participants were not inclined to make riskier or less risky choices when evaluating risk in either processing mode, implying that it is possible to influence the way in which risk is processed *without* influencing actual risky choice behaviour. In sum, these findings provide the first direct support for dual-process models of risky choice.

When considering these results, it should be noted that this study used vignettes, which are unlikely to trigger very strong emotions. Real-life situations may invoke stronger affective reactions that may override cognitive considerations. Sunstein (2003), for example, showed that when strong emotions are involved, people tend to ignore the likelihood of occurrence of a negative event and focus only on the bad outcome itself. Also, the impact of visceral states could reduce the influence of cognitive considerations to a minimum or eliminate them altogether (see e.g. Loewenstein, 1996). Therefore, future research may use situations that trigger more intense emotions to evaluate their influence on risk perception and -choice. Loewenstein et al. (2001) argue that '[e]liciting powerful emotions in normal populations is certainly problematic; perhaps the best opportunities for such research occur in naturalistic settings in which emotions reliably run high (e.g. just before parachuting, or in the courtroom). But even under 'normal' circumstances the question what characteristics of the context make either cognition or affect dominant in a decision-making situation deserves more investigation. We coincide with Finucane et al. (2000, p. 14) who argued that the '[r]eliance on

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affect probably ebbs and flows according to various contextual factors, including the extent to which stimuli evoke images that are tagged clearly with positive or negative feelings'. Future research should therefore focus on the influence of contextual factors on risk perception and risky choice in order to increase our understanding of how they influence cognitions, feelings and our behaviour.

A particular interesting future line of inquiry with regard to dual-process models and risky choice concerns the comparison of well-defined situations with known probabilities and information about risk magnitude versus more ambiguous situations where these parameters are unclear or unknown. Risk research and decision theory has tended to favour the former kind, yet most real-world situations tend to be of the latter variety. It may well be that cognition-based processing tends to dominate in well-defined risk situations. The question that remains is how we can pursue a risk-as-analysis strategy when the input for analysis is vague, unreliable or even absent.

Another question regards how we can optimally benefit from both modes of processing and in what situations we should give more importance to either our feelings or our thoughts (see e.g. Damasio, 1994). Triggering or activating processing mode by means of the presentation of information may prove especially relevant with respect to informing the general public about risk and trying to optimize the impact of campaigns to this end. To return to the question posed in the introduction of this paper: when should appeals be directed to cognitive considerations and be aimed at changing beliefs by means of statistics and probabilities? And when should efforts rather be directed at changing the feelings associated with risks and risky behaviour? Discussing policy against terrorist threat, Sunstein argues: '(. . .) government is unlikely to be successful if it attempts to reduce fear by emphasizing the low likelihood of another terrorist attack. It might do better if it changes the subject or instead stresses the affirmative social values associated with running the risk' (2003, p. 122). Implicit in this example are again the two separate processing modes and the limited use of appealing to cognitive considerations when a risk is evaluated on an affective basis. Terrorist threat appears to be a paradigm example of such a risk due to the strong affective imagery this type of risk evokes and appeals to 'use one's head' will indeed be unlikely to generate much effect in this case.

APPENDIX: VIGNETTES

Airplane

Imagine the following

You are going on holiday to a destination on the Mediterranean Sea with a group of friends. You just heard on the news that the airline you are supposed to fly with has been warned for the bad maintenance of its aircraft. Last week one of the planes of the airline had a problem and had to make an emergency landing. This incident has led the French government to issue a prohibition to land for the aircraft of the airline until they meet the safety requirements. Inquiries at the travel agency where you booked the flight made it clear that it is impossible to cancel your flight and get a refund because the flight is still normally scheduled for departure.

Exams[1]

Imagine the following

You are about to leave your house one morning to take an important exam and you are running late. On the radio you hear the weather forecast by the National Meteorological Institute, which issues a warning that the roads are very slippery due to icing and strongly advices people not to go on the road unless absolutely necessary. It's about 15 minutes cycling to the place where you have to take your exam. Just before mounting

[1]When reading this vignette it should be taken into account that in the Netherlands most people own bikes and that in the city of Amsterdam, where the study was conducted, bikes are the principal mode of transportation and estimates of the number of bikes equal the number of inhabitants of the city.

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your bike you notice that the street is indeed extremely slippery. Due to the weather, public transportation is disrupted and there is no way of getting a taxi on short notice. If you walk you'll be late for sure. The only possible way to get to there in time is by bicycle.

Going Out

Imagine the following

You are on your way on your bike to a café where you are supposed to meet some friends. From your house it is about half an hour cycling to the café. Just before arriving at your destination one of your friend calls you on your cell phone and warns you that there are preventive ID checks at different locations in the city and also around the café. You had not anticipated this and therefore do not carry an ID with you. As a rule there are no exceptions made and everybody who gets checked and does not carry his ID has to pay a fine of 50 euros.

Drink 'n Drive

Imagine the following

You are at a birthday party an hour's drive from your home. You agreed with a friend, with whom you are at the party, that he/she would drive you back home since you don't have a drivers licence. When the party is over, you notice that your friend is quite drunk. There is nobody at the party from your hometown who can give you a ride, and there is no public transport. You deliberately stayed sober because you have an important job interview in the morning'.

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